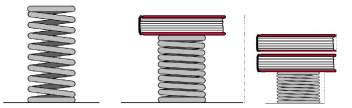
Newton's Laws Summary

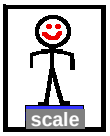
- ***1st Law: Law of Inertia***
  - An object in motion tends to remain in the same state of motion unless acted upon by an outside force.
  - An object at rest tends to remain at rest unless set into motion by an outside force.
- ***2nd Law: Law of Motion***
  - ***Force*** = ***mass*** x ***acceleration*** ($F = ma$)
  - ***Mass*** = quantity of matter
  - ***Acceleration*** = change of speed with time
- ***3rd Law: Law of Reaction***
  - For every action, there is an equal and opposite reaction
  - (The two forces act in different objects)

How does a Scale Work?

- First let's look at a spring



$F_{spring} = 0$ $F_{spring} = mg$ $F_{spring} = 2mg$

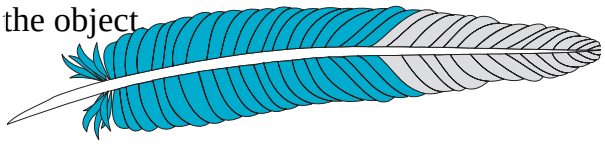


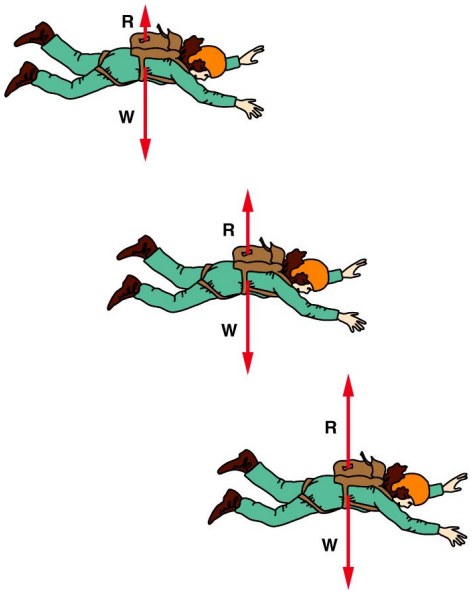
- A scale has a set of springs on the inside
- When you stand on the scale:
  - The weight force pull you towards the Earth
  - The scale spring force pushes you upward
- Since you are not moving the net force is zero

Use equilibrium Condition: $F_{spring} - mg = 0$ $F_{spring} = mg$

Drag or Air Resistance

- Drag or air resistance is the force which opposes an object moving through air
- Drag tends to increase as the object moves faster
- The amount of drag depends on the shape of the object





1. Suppose one's hand exerts a force of 12 N upward on a book weighing 10 N. The reaction to the force of the hand on the book is a force of

A. 10 N exerted by the Earth on the book.
B. 10 N exerted by the book on the Earth.
C. 12 N exerted by the book on the hand.
D. 10 N exerted by the book on the hand.
E. 2 N exerted by the book on the hand.

2. A 100-pound sack of potatoes falls from an airplane. As the velocity of the falling sack increases, so does the air resistance on it. When the air resistance equals 100 pounds, the acceleration of the sack will be

A. infinite.
B. 9.8 m/s^2.
C. 9.8 m/s.
D. zero

3. A 5.0 kg block on a smooth horizontal surface is acted upon by two forces: a horizontal force of 40 N acting to the right and a horizontal force of 10 N to the left. The acceleration of the block will be:

A. 6.0 m/s^2 to the right
B. 10.0 m/s^2 to the right
C. 8.0 m/s^2 to the right
D. 5.0 m/s^2 to the right.

4. Your mass is 50 kg. Suppose you are standing on a scale in an elevator which starts moving up and increases its speed at the rate of 2 m/s every second. What would be the reading on the scale?

A. 590 N
B. 490 N
C. 390 N
D. 100 N
E. 0

Kinematics

- Kinematics is the science of describing the motion of objects using words, diagrams, numbers, graphs, and equations.
- The goal of kinematics is to develop sophisticated models we can use to describe the motion of real-world objects.

Average Speed

- Speed is a measure of how fast an object is moving.
- Average speed is equal to the distance traveled divided by the time of travel or:

$$\text{Average Speed} = \frac{\text{Distance traveled}}{\text{time to travel}}$$

using symbols $s = \frac{d}{t}$

units for speed are:

meter/second miles/hour=MPH kilometer/hour

MKS units

Typical Values of Speed

- Slug 2 mm/s=0.002 m/s
- Walking person 1.5 m/s
- Baseball (fast ball) 45 m/s
- Race car (formula 1) 100 m/s
- Sound 340 m/s
- Space Shuttle (in orbit) 8000 m/s
- Light $3x10^8$ m/s=300,000,000 m/s

Instantaneous Speed

- Instantaneous Speed is the speed at any given instant in time.
- Instantaneous Speed can be found by calculating the average speed over a very short interval of time (so that the speed doesn't change very much).

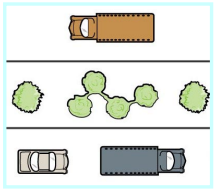
Velocity

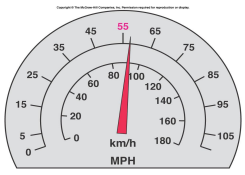
- Velocity describes how fast an object is moving and its direction of motion.

Velocity = speed & direction

- Velocity is a vector quantity. As such, velocity is "direction-aware". The direction of the velocity vector is always the direction of motion.

An everyday example





- *The speedometer of the blue truck moving to the **east** reads **90km/h**. It passes another truck that moves to the **west** at **90km/h**.*
  - *Do both trucks have the same speed?* **Yes**
  - *Do they have the same velocity?* **No**

Average Acceleration

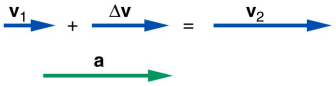
- Acceleration is the rate at which velocity changes with time.

$$\text{Acceleration} = \frac{\text{change in velocity}}{\text{elapsed time}} = \frac{v_{final} - v_{initial}}{\text{elapsed time}}$$

In symbols: $a = \frac{\Delta v}{t} = \frac{v_2 - v_1}{t}$

- Direction of the acceleration is the same as the direction of the change in velocity, it might not be the same as the direction of motion.
- Acceleration is measured in m/s^2

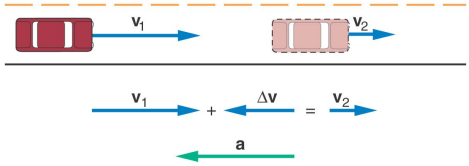
A car speeding up….

graphically 

in symbols $a = \frac{\Delta v}{t} = \frac{v_2 - v_1}{t}$

- The acceleration is in the same direction as the velocity, that is the acceleration is in the direction of motion.

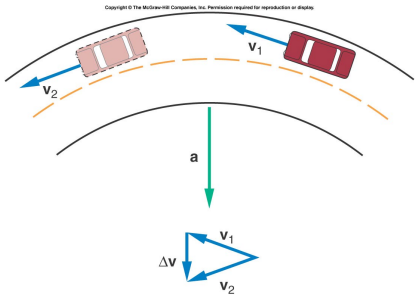
A car slowing down….



in symbols $a = \frac{\Delta v}{t} = \frac{v_2 - v_1}{t}$

- The acceleration is in the opposite direction relative to the velocity, that is the acceleration is in the opposite direction relative to the direction of motion.

A car going around a curve at a constant speed



- The vector difference between v_2 and v_1 is not zero therefore the car is accelerating while going at a constant speed!